REMARKS

Claims 1-22 are pending.

In the Office Action, claims 1-22 are rejected under 35 U.S.C. § 103(a) as being obvious in view of Thorburn et al. (US 2003/0047674 A1) and Kaneda et al. (US 5,483,377). This rejection is respectfully traversed.

Claim 1 is directed to an optical encoder sensor head for use with a reflective multi-track encoder scale, which includes (1) a quasi-monochromatic light source disposed on a surface of a planar substrate facing the encoder scale, (2) a plurality of optical detectors disposed on the surface of the substrate at respective locations defining respective optical paths between the optical detectors and respective tracks of the encoder scale, and (3) an optical wavefront dividing element disposed between the substrate and the encoder scale, the optical wavefront dividing element being operative to divide an incident light beam produced by the light source into a plurality of diffracted light beams, each diffracted light beam being directed toward a respective track of the encoder scale at a respective angle so as to be reflected from the respective track along the optical path to the respective detector (emphasis supplied).

As described in the previous response, the sensor head of claim 1 is directed to the problem of improving efficiency and performance of multi-track optical encoders by splitting incident light from the light source into two beams that are each directed to be reflected from a respective track to a respective optical detector. It is possible to illuminate two tracks from a relatively narrow source such as a VCSEL while maintaining close encoder-to-scale spacing and avoiding an undue increase in the VCSEL output power solely for the purpose of covering multiple tracks. The Examiner is directed to Figure 3 of the present application, which shows an embodiment in which beams 105a and 105b are directed to respective tracks (main track 162 and index element 166) and then reflected as beams 106a and 106b to respective detectors 140 and 120.

Thorburn et al. shows a "reference point" Talbot encoder having a sensor head 110 including a light source 112, a detector array 120, and an index detector 140 all of which are disposed on a substrate 111. A scale 160 is

disposed opposite the sensor head and is disposed for movement relative to the sensor head along a line A-A. The distance between the scale and the sensor head is selected so that the detector array lies near a talbot imaging plane. The light source emits a diverging beam of light, which is directed towards the scale. Light from the diverging beam of light is diffractively reflected by a grating 162 towards the detector array. Light from the same diverging beam of light is also diffractively reflected by an index optical element 166 towards the index detector. The detector array provides a measurement of the position of the sensor head relative to the scale in the direction A-A. The index detector provides a reference measurement of the position of the sensor head relative to the scale in the same direction.

As shown in Figure 1 of Thorburn for example, there is but a single beam or cone of light 102 that illuminates both the grating 162 and the index optical element 166. Thus there are not two beams, and as noted in the Office Action, Thorburn does not show an optical wavefront dividing element disposed between the substrate and the scale. Additionally, Thorburn is not seen to mention any problems associated with having a single cone of light 102 illuminate both the grating 162 and the index optical element 166, nor any other problems or motivations for employing two beams instead of one.

Kaneda shows a displacement detection apparatus having a light source 1, a first diffraction grating G1 including a blazed grating for diffracting and splitting light from the light source to irradiate a 0-order diffraction light and a +1-order diffraction light to a second diffraction grating G2, a third diffraction grating G3 including a blazed grating for combining a +1-order reflected diffraction light produced by the reflection and diffraction of the 0-order diffraction light by the second diffraction grating and a -1-order reflected diffraction light produced by the diffraction of the +1-order diffraction light by the second diffraction grating to produce an interference light, and a photo-sensing element 3 for converting the interference light to a signal representing a change in the second diffraction grating (i.e., relative X-direction movement of the grating G2 with respect to gratings G1 and G3 as depicted in Figure 1). Thus in Kaneda the purpose of

splitting light from the source is merely to make diffractive orders that ultimately are directed back to a single location on grating G3 to create a single interference pattern (mixing of beams R0+1-1 and R+1-10) to modulate the intensity of light incident on a single detector G3 as a function of X-direction displacement of the grating G2.

The Office Action asserts that it would be obvious to use the gratings G1/G3 of Kaneda in the encoder of Thorburn, specifically "to improve the splitting of the incident light (R0, R+1) generated by the light source (1) wherein the reflected divided light (R0+1, R+1-1) is directed toward the corresponding detector elements allowing the distance between the scale (G2) and the encoder to be measured (see Figure 2B, column 2, lines 53-67, column 3, lines 1-65)." Notwithstanding these assertions in the Office Action, it is respectfully submitted that (1) there is in fact no motivation in these references to make the proffered combination, and (2) even if such a combination were to be made, the result would not be the subject matter of claim 1.

To begin with, it is respectfully noted that the purpose of the position detector of Kaneda is to detect motion in the X direction (left-right in Figure 2B), not to measure distance between the scale G2 and the rest of the encoder. Additionally, there is no splitting of light in Thorburn, and therefore no need for any "improved splitting" that Kaneda may or may not offer. Thus, the motivation proffered in the Office Action actually has no support within either Kaneda or Thorburn.

The displacement detection apparatus of Kaneda operates on the principle of using a first grating G1 to create multiple diffraction orders separated in the direction of interest (e.g., the X direction), then by action of the reflective grating G2 to create corresponding additional diffractive orders also in the X direction and direct them to a third grating G3, where two orders of interest form an interference pattern that interacts with the grating G3 to modulate the intensity of light provided to the detector 3. There are not two tracks in Kaneda, but rather only one track which is the grating G2. Although the grating G1 does indeed split the light from the source 1, it splits it only into diffractive orders that are directed

to different locations on the one track G2, not to two different tracks. Moreover, there is clearly only one detector in Kaneda, which operates in response to the interference pattern created by two diffractive orders R+1-1 and R0+1 reflected from the one grating G2.

The optical encoder of Thorburn operates by a different principle. It includes a main track 162 and a corresponding detector 120. Referring to paragraphs 42-47 of Thorburn, the track 162 is illuminated by an expanding cone of light that is reflected to the detector 120. The reflected light includes a fringe pattern with a period T in the direction of relative motion. The detector 120 includes a plurality of rectangular photodetectors. Motion of the scale 160 in the direction of arrow A-A (corresponding to the X direction in Kaneda) causes the fringe pattern to move across the detector array 120. It is the direct interaction between the fringe pattern and the multi-element detector array that causes the encoder electrical output to vary as a function of the relative position of the scale 160 along line A-A. There is no use of, nor any need for, any interposed grating such as G1/G3 of Kaneda to either create diffraction orders or to interact with interference patterns of diffraction orders so as to create the encoder output signal.

It is further noted that there is also no motivation to use the G1/G3 gratings of Kaneda to direct diffraction orders to different tracks such as the index element 166 and grating 162 of Thorburn. Thorburn itself teaches only one beam. Additionally, Thorburn's tracks 162 and 166 are separated in a direction orthogonal to the direction of motion A-A. Kaneda teaches the creation of diffraction orders in the direction of relative motion (X direction), not in a direction orthogonal to the direction of motion to be incident on multiple tracks. Nowhere does Kaneda betray any concern about illuminating multiple tracks, nor any other reason for directing diffraction orders in any direction other than along the direction of motion X. Specifically, Kaneda does not teach or suggest rotating the G1/G3 gratings by 90 degrees to separate the beams R0 and R+1 in the Y direction rather than the X direction, as would be required if it were to illuminate the two different tracks 162 and 166 of Thorburn.

Based on the above, there is no motivation in Thorburn and Kaneda to utilize the gratings G1/G3 of Kaneda in the encoder taught in Thorburn.

Beyond the foregoing, even if the G1/G3 gratings of Kaneda were to be somehow included in the encoder of Thorburn, the result would not fall within the scope of claim 1. Kaneda teaches creating and directing diffractive orders to two areas of a single track G2 along an X direction of relative motion, from which they are reflected and eventually recombined by grating G3 into a light pattern directed to single detector 3 in Kaneda. If the G1/G3 gratings of Kaneda were to be included in the encoder of Thorburn, the result would be that whatever light passes through grating G3 would still be incident on only one detector (e.g. 120) of Thorburn.

Finally, even if Kaneda's G1/G3 grating were turned 90 degrees to direct diffraction orders R0 and R+1 to the Y-separated tracks 162 and 166 of Thorburn, it should be clear that no coherent result would be obtained. Thorburn's tracks 162 and 166 do not diffract light in that orthogonal direction, and thus the diverging diffraction orders R0 and R+1 would simply continue to diverge in the Y direction after being reflected by the tracks 162 and 166, and never re-combine at the grating G3. The function of the G1/G3 gratings would have been destroyed. There is no evidence in either of these references that suggests such an apparently facetious configuration.

Based on the foregoing, it is respectfully submitted that the combination of Thorburn and Kaneda cannot render claim 1 obvious under 35 U.S.C. § 103. There is no motivation to combine the teachings of these references in the manner suggested in the Office Action, and even if such a combination were made, the result would not fall within the scope of claim 1. Accordingly, claim 1 is seen to be non-obvious in view of these references.

As all the claims of this application include, either directly or indirectly, features such as those discussed above with reference to claim 1, the above arguments are seen to be dispositive with respect to the non-obviousness of all the claims in view of the combination of Thorburn and Kaneda. Accordingly, it is not seen to be necessary at this time to address the various assertions and

conclusions set forth in the Office Action with respect to the remaining claims. Applicant does not in any way acquiesce to any of those assertions and conclusions, and specifically reserves the right to rebut any and all statements in the Office Action regarding the non-patentability of the remaining claims.

Notwithstanding the foregoing, it is desired to address claim 22 specifically. It is respectfully urged that the combination of Thorburn and Kaneda clearly does not teach or suggest the subject matter of claim 22, which includes a specific relationship among several dimensions of the encoder according to the equation:

$$\tan\left(\lambda/_{P}\right)=\frac{Y+d}{2(2D-Z)}$$

Although the Office Action states that this relationship is "functionally equivalent" to an equation $(Z_0Z_1/(Z_0+Z_1) = NP^2/\lambda$ shown in Thorburn, this statement is completely unsupported and incorrect in any event. The equation of claim 22 captures a relationship between the Y-direction separation of two detectors and the period P of a periodic grating pattern of a wavefront dividing element that creates the two beams directed to the two detectors, among other things. The equation appearing in Thorburn relates the Z-direction spacing of so-called "talbot" self-imaging planes to various parameters including Z-direction spacing of the light source and the reflective grating. This equation in Thorburn says absolutely nothing about how to choose parameters so as to direct two beams to detectors separated in the Y direction, and therefore cannot serve as a basis for rejecting claim 22.

In view of the foregoing remarks, this Application should be in condition for allowance. A Notice to this affect is respectfully requested. If the Examiner believes, after this Response, that the Application is not in condition for allowance, the Examiner is respectfully requested to call the undersigned Attorney at the number below.

Applicants hereby petition for any extension of time which is required to maintain the pendency of this case. If there is a fee occasioned by this response, including an extension fee, that is not covered by an enclosed check, please charge any deficiency to Deposit Account No. 50-3661.

If the enclosed papers or fees are considered incomplete, the Patent Office is respectfully requested to contact the undersigned collect at (508) 616-2900, in Westborough, Massachusetts.

Respectfully submitted,

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